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DECUS NO.	8-593
TITLE	TRI-DATA PAPER TAPE PAL III ASSEMBLER
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DATE	December 21, 1972
SOURCE LANGUAGE	PAL III

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TRI-DATA PAPER-TAPE PAL-III ASSEMBLER

PURPOSE

This program is a revision of the PDP-8 basic PAL-III assembler. Additional features include card-reader and line-printer I-O, a symbol table capacity of up to 3550 symbols (16K system), paginated and formatted listings with line numbers, and the availability of a compacted source-tape format.

DESCRIPTION

The Tri-Data Paper Tape PAL-III Assembler program duplicates the functions of the basic PAL-III assembler for PDP-8 programs. Aside from certain changes in the FIXTAB and FIXMRI pseudo-opcode usage (see below), any program written in PAL-III symbolic language may be processed through this assembler. It shall be assumed in the remainder of this writeup that the reader is familiar with the operation and syntax of the standard PAL-III paper-tape assembler for PDP-8 computers.

The assembler allows a wide range of input-output devices to be used during an assembly run. I/O device assignments are made at the beginning of the first assembly and remain fixed thereafter; device assignments may be changed only by reloading the assembler. Source-program input may be from the teletype reader, high-speed reader, or CR/8 card reader. Source programs may be sectioned onto as many paper-tapes as desired; the assembler allows a new tape to be loaded whenever the old tape is exhausted or a PAUSE pseudo-op is encountered. Binary-tape output may be to a teletype punch or high-speed punch. Binary paper-tapes have the standard PDP-8 binary format. Listing output may be to a teletype, high-speed punch, LP08 line-printer or type 645 line-printer. Listings may be output with or without form-feeds; if form-feed hardware is not present, the assembler will print cutoff lines so that roll-stock listings may be cut into 11" pages.

The assembler source listing has been greatly improved. In addition to the pagination features described above, the listing is automatically formatted into neat columns by the use of spaces and slashes. A space before column 9 of a source statement causes the listing to "tab" to column 9. A slash before column 25 of a source statement causes the listing to "tab" to column 25. These rules do not apply to an entire line of comments whose slash appears in column 1. In addition, multiple spaces before the start of comments will be printed as one space, and a tab character will be interpreted as a space (but will not cause a hardware "tab"). Thus, all operands on a source line need be separated by only one space; a line containing no symbol need have only one leading space; and a slash may directly follow the last operand. These rules cause columns 1-8 to be used for tags, columns 9-24 to be used for operands, and the remainder of a line starting at column 25 to be used for comments.

Each listing line will be numbered in a manner corresponding to the "pages" of the PDP-8 editor. The listing "page" number is incremented and printed each time a form-feed character is read, and the source statements are numbered consecutively within each page. Also, the symbol table will be paginated and printed in four columns, rather than one. An undefined symbol will be flagged with an asterisk, and the address printed with an undefined symbol shall be the address at which the symbol was first seen.

All diagnostic messages found in the standard PAL-III remain in this assembler and are used identically. Both the UA and IR diagnostics will be output during all passes except pass 1. Either of these diagnostics will cause an octal zero to be output on the binary tape along with a checksum of zero. This allows minor errors to be corrected by "patching" a binary paper-tape where a reassembly is not desired. Extraneous commas and equal-signs (which do not define a symbol) will cause the IC diagnostic to be output, rather than causing an assembler error as before.

The permanent assembler symbol table includes symbol definitions for all basic PAL-III symbols. In addition, symbol definitions for time-sharing, EAE, power failure, memory parity, card-reader, and line-printer have been included; the DECTAPE and DECDISC symbols have been deleted. The assembler as distributed has a capacity of 486 user symbols on a 4K system, 1510 symbols on an 8K system, 2534 symbols on a 12K system, or 3558 symbols on a 16K system. This assembler uses a binary-search method of scanning the symbol table so that large programs with many symbols may be processed without loss of assembly speed. The assembler may be loaded into any memory field and will use additional fields of memory above itself; it is the user's responsibility not to assign a nonexistent memory field to the assembler. The last 128 words of the uppermost assembler field (assumed to contain a binary loader) will not be used for symbol table storage.

RESTRICTIONS

This program does *not* output a symbol table having a format acceptable to the dynamic debugging program (DDT). Thus, DDT may not be used to debug programs produced by this assembler.

The four sections of the assembler symbol table (pseudo-opcodes, memory-reference instructions, micro-opcodes, and user symbols) *must* be present in the preceding order and *must each* be in alphabetical order by symbol. The assembler will *not* re-alphabetize a new memory-reference or micro-op symbol that is added to the permanent symbol table. Consequently, if it is desired to make any change to the permanent symbol table, then the entire table must be changed as follows:

- 1) Submit an EXPUNGE pseudo-op.
- 2) Define all memory-reference instructions.
- 3) Submit one FIXMRI pseudo-op.
- 4) Define all permanent micro-op symbols.
- 5) Submit a FIXTAB pseudo-op.

If the user desires to obtain a new binary tape of the assembler with a revised symbol table, the following procedure must be used:

- 1) Load the original Paper Tape PAL-III assembler.
- 2) Load the DEC binary-punch program.
- 3) Start the assembler at 0200 and make all permanent symbol definitions, as described above.
- 4) Use the binary-punch program to punch a binary tape of locations 0104-0106 and locations 2704 to the end of the symbol table. The ending symbol table location is equal to the contents of location 0105 times 4, plus 2637.

- 5) Reload the original Paper-Tape PAL-III assembler.
- 6) Load the symbol-table tape punched in step 4.
- 7) Use the binary-punch program to punch a tape of locations 0027-2175, 2210-2212, 2251, 2512 through the end of the symbol table (as defined in step 4), and 6000-6564. The tape so punched is the updated Paper Tape PAL-III assembler.

OPERATING PROCEDURES

- 1) Load the Paper Tape PAL-III assembler from magnetic tape using the binary loader, and initiate the assembler at address 0200.
- 2) The assembler will type its title and will type the message "INPUT UNIT: ". Type an input-unit code, followed by a carriage-return. Allowable input-unit codes are T for teletype reader, R for high-speed reader, and C for card-reader.
- 3) The assembler will type "BINARY UNIT: ". Type a binary-unit code, followed by a carriage-return. Allowable binary-unit codes are T for teletype punch or P for high-speed punch.
- 4) The assembler will type "LISTING UNIT: ". Type a listing-unit code, followed by a carriage-return. Allowable listing-unit codes are T for teletype, P for high-speed punch, L for LP08 line-printer or 6 for type 645 line-printer.
- 5) The assembler will type "LISTING FORM-FEEDS: ". Type a form-feed code, followed by a carriage-return. If form-feed hardware is to be used on the listing unit (or if a paper-tape will ultimately be listed on such a listing unit), type Y (yes); otherwise type N (no). The 645 line-printer is assumed to have form-feed hardware, and thus the form-feeds message will not be typed if a 645 printer is the listing unit.
- 6) The assembler will type "MEMORY FIELDS: ". Type the number of 4K fields to be used by the assembler, followed by a carriage-return. This must be a number between 1 (4K) and 4 (16K). Note that the assembler will only use fields higher in number than the field in which it is loaded. Each field above the first allows the assembler to hold 1024 additional symbols.
- 7) The assembler will type "PASS=". Type the desired pass number, an N if no symbol table is desired (not necessary during pass 2), and a carriage-return. All I/O devices must be ready for use before the pass number is entered, as the assembler will begin the pass immediately afterward. The pass number must be 1, 2, 3, or 4. Passes 1-3 perform the same functions as in the standard PAL-III. Pass 4 is a combination of pass 2 and 3; the assembler will produce both a binary tape and a listing simultaneously, thus saving time. Note, however, that pass 4 is illegal if the same I/O device is specified as the listing and binary unit (e.g., only a teletype is used).
- 8) When each pass is completed, the assembler will retype the "PASS=" message and wait for the operator to initiate the next pass. As many assemblies as desired may be run, and the assembler may be restarted at any time at address 0200. Note, however, that I/O and memory assignments may be changed only by reloading the assembler.

- 9) If an error is made while typing any reply, the operator may type a rubout or any illegal character to cancel the reply. The assembler will retype the message and reread the operator reply. Also, the entire initialization sequence may be restarted by typing a backarrow (shift-O) at any time before completing the memory-fields entry.
- 10) During pass 1, a diagnostic listing will always be output on the listing device, even if it consists of only one blank page. If the high-speed punch is the listing device, it must be turned on during pass 1.
- 11) The assembler halts at the following addresses when the indicated condition is detected:

<u>Halt Address</u>	<u>Meaning</u>
0653	A PO, PU, or ST error has occurred. The appropriate error diagnostic has been typed out. This is a dead-end halt; the source program must be analyzed and corrected.
1174	A "PAUSE" pseudo-op has been processed. Load the next paper-tape into the input device and press CONTINUE.
1236	Card-reader error or end of card input. Clear the error and/or load the next deck of input cards, and press CONTINUE.
1251	End of input paper-tape. Load the next paper-tape into the reader and press CONTINUE.